

REMARKS

Applicants have amended their claims in order to further clarify the definition of various aspects of the present invention. Specifically, Applicants have cancelled the claims directed to electrodes (that is, claims 15, 17-19 and 36) without prejudice or disclaimer, and in particular, without prejudice to the filing of a Continuing application directed to the subject matter thereof. Moreover, Applicants have amended independent claims 13, 14, 20 and 24 to recite that the graphite powder has substantially completely a crystal structure, and to recite that the graphite powder has a deintercalating capacity for lithium of at least 320 mAh/g. In light of amendments to the independent claims, Applicants are canceling claims 34, 35, 37 and 38 without prejudice or disclaimer.

Applicants respectfully submit that all of the claims presented for consideration by the Examiner patentably distinguish over the teachings of the prior art applied by the Examiner in rejecting claims in the Office Action mailed February 10, 2005, that is, the teachings of the U. S. Patents to Takami, et al., No. 5,340,670, and to Flandrois, et al., No. 5,554,462, under the provisions of 35 USC 102 and 35 USC 103.

It is respectfully submitted that these references as applied by the Examiner would have neither taught nor would have suggested such a non-aqueous secondary battery as in the present claims, including, inter alia, wherein the negative electrode includes graphite powder having substantially completely a crystal structure, the graphite powder having a particle size equal to or smaller than 100 μm and a deintercalating capacity for lithium of at least 320 mAh/g, as in claims 13, 14, 20 and 24, with a rhombohedral fraction, of the crystal structure of the graphite

powder, being in a range of 0-20% by weight (see claim 13; note also claim 20), or wherein a hexagonal fraction, of the crystal structure of the graphite powder, is in a range of at least 80% by weight (see claim 14), or wherein a fraction of the rhombohedral crystal structure is equal to or less than 20% by weight and a fraction of the hexagonal crystal structure is equal to or more than 80% by weight (see claim 24). Note also claims 21, reciting that a fraction of hexagonal crystal structure, of the crystal structure of the graphite powder having the specified rhombohedral structure, is equal to or more than 80% by weight; and claims 32 and 33, reciting that the crystal structure of the graphite powder includes at least a fraction having hexagonal crystal structure.

The invention as claimed in the above-identified application is directed to a non-aqueous secondary battery using a negative electrode made of graphite powder. The present invention has use, for example, in connection with a lithium battery, and provides such battery which can have a high energy density and a long life, and which has excellent intercalation capacity (that is, an increased capacity of the battery).

Carbon material has been proposed as negative electrode active material in place of lithium metal, in lithium batteries, in which charge and discharge reactions involving lithium ion intercalation into the carbon material and deintercalation from the carbon material occur. However, in previously proposed batteries (e.g., lithium secondary batteries) using carbon material as active material for the negative electrode, a large capacity cannot be obtained; and, moreover, preferable performances of rapid charging and discharging are not obtained. Note the paragraph bridging pages 2 and 3 of Applicants' specification.

Against this background, Applicants provide a non-aqueous secondary battery using a negative electrode with carbon powder as active material, which active material has good charging and discharging characteristics, while having a large capacity (large intercalation capacity). Applicants have found that by using graphite powder having substantially completely a crystal structure, with this crystal structure being at least 80% hexagonal crystal structure and/or at most 20% rhombohedral crystal structure, for the overall structure of the graphite powder (which graphite powder, e.g., has laminated graphite layers); and, in particular, by limiting the amount of rhombohedral crystal structure of the graphite powder and increasing the amount of hexagonal crystal structure thereof, various advantages are achieved. In particular, by reducing the amount of crystal structure, of the graphite powder, which is rhombohedral and increasing hexagonal crystal structure, intercalation capacity of the negative electrode is increased. That is, the number of storage sites for lithium in the negative electrode is increased.

The present invention focuses on the crystal structure of the graphite powder, requiring that the graphite powder has substantially completely a crystal structure and the crystal structure is constituted of hexagonal crystal structure of at least 80% by weight and rhombohedral crystal structure in a range of 0-20% by weight. The graphite powder according to the present invention has increased hexagonal crystal structure, due to an orderliness and regularity of the hexagonal-net-plane layers. That is, it is respectfully submitted that the fundamental hexagonal crystal structure, of the substantially complete crystal structure of the graphite powder according to the present invention, is achieved based upon regularity and orderliness of the lamination. In accordance with the present invention, the existing ratio of hexagonal crystal structure, of the substantially complete crystal structure of the graphite

powder as a whole, is specified at a high level, and/or the rhombohedral crystal structure is at a low level, in order to achieve the increased capacity of the battery as described in Applicants' disclosure.

In comparison, and as will be discussed infra, Takami, et al. discloses crystallites and structure with hexagonal-net-plane layers, which are laminated; however, this reference is silent with respect to orderliness and regularity of the laminated hexagonal-net-plane layers. More specifically, it is respectfully submitted that Takami, et al. teaches away from such orderliness and regularity (e.g., a substantially complete crystal structure) of the laminated hexagonal-net-plane layers, in describing that the hexagonal-net-plane layers stacked in the graphite structure "have appropriate displacements, twists and angles to one another", so that when the stacked hexagonal-net-layers have appropriate displacements, twists, and angles to one another, lithium ions diffuse more easily between the hexagonal-net-plane layers, so the carbonaceous material presents a property of reversibly, rapidly absorbing and desorbing a large number of lithium ions. See column 7, lines 29-40.

In the Office Action mailed February 10, 2005, the Examiner characterizes Applicants' arguments in the second paragraph on page 4 thereof, that Takami, et al. "has [minimum] twisted structures unlike [Applicants'] structure". It is respectfully submitted that this is a misunderstanding of Applicants' arguments and misconstrues the present invention. That is, it is respectfully submitted that Takami, et al. specifically discloses the need for twisted structures, thus having a number of twisted structures. In comparison, the present invention has a substantially complete crystal structure, substantially without twisted structures as required by Takami, et al. As contended previously, and as will be discussed further infra, it is respectfully submitted that the disclosure of Takami, et al. in connection with "displacements,

twists and angles" of the hexagonal-net-plane layers to one another would have taught away from the substantially complete crystal structure with the recited hexagonal/rhombohedral crystal structure, and advantages thereof with respect to increased intercalation capacity of the negative electrode.

Furthermore, and as will also be discussed further infra, Takami, et al. discloses crystallites, and structure with hexagonal-net-plane layers which are laminated; however, it is respectfully submitted that this reference is silent with respect to orderliness and regularity of the laminated hexagonal-net-plane layer; and, in particular, it is respectfully submitted that this reference is silent in connection with the substantially complete crystal structure. In connection with differences between crystallites and crystals, attention is again respectfully directed to the definition of "crystal" and of "crystallite" on page 327 of Hawley's Condensed Chemical Dictionary (12th Ed. 1993), submitted with the Submission (Amendment) filed November 22, 2004. As can be appreciated therefrom, a crystallite is that portion of a crystal whose constituent atoms, ions or molecules form a perfect lattice, without strains or other imperfections, and is usually microscopic (while crystals may be quite large). Taking the disclosure of Takami, et al. as a whole, including the disclosure therein of "appropriate displacements, twists and angles" of the planar layers to one another (note, for example, column 7, line 21-40 of Takami, et al.), it is respectfully submitted that Takami, et al. would have neither disclosed nor would have suggested, and in fact would have taught away from, the crystal powder having a substantially complete crystal structure, and especially with specified fractions of the crystal structure being hexagonal and/or rhombohedral, as in the present claims, and advantages thereof.

To emphasize, in accordance with the present invention, graphite powder of a relatively small size, is used as material for the negative electrode, and a focus thereof is on a substantially complete crystallinity of the graphite powder. Applicants have found that by using graphite powder having a substantially complete crystal structure, and having a relatively large amount of this crystal structure being hexagonal crystal structure; and, in particular, with this crystal structure of the graphite powder having a specific ratio of hexagonal crystal structure to rhombohedral crystal structure, improvements in capacity are achieved. That is, according to the present invention the graphite powder has a substantially complete graphite crystal structure, and Applicants limit the amount of rhombohedral structure and increase amount of hexagonal crystal structure, with orderliness and regularity between the laminate layers of the graphite (e.g., a substantially complete crystal structure), so as achieve unexpectedly better results of increased capacity, as seen in Applicants' disclosure.

In the first full paragraph on page 3 of the Office Action mailed February 10, 2005, the Examiner contends that in view of the recited exothermic peak and intensity ratio of two different diffraction peaks, obtained by X-ray diffraction analysis, in Takami, et al., these values indicate a crystal structure for the entire anode material, the Examiner contending that a material would necessarily have to comprise an entire crystal structure to exhibit such analysis when undergoing X-ray diffraction procedures. However, it is respectfully submitted that these contentions by the Examiner are totally inconsistent with express teachings of Takami, et al., of graphite structure having "appropriate displacements, twists and angles to one another". From the express teachings of Takami, et al., of crystallites, wherein the stacked hexagonal-net-plane layers have appropriate displacements, twists and

angles to one another, such rebuts the conclusion by the Examiner as to a crystal structure for the entire anode material in Takami, et al.

The contention by the Examiner in the paragraph bridging pages 2 and 3 of the Office Action mailed February 10, 2005, that not all of Applicants' claims require the entire anode carbon material to be of a crystal structure, is noted. Attention is respectfully directed to the claims of the above-identified application, as presently amended, reciting that the negative electrode comprises graphite powder having substantially completely a crystal structure; thus, it is respectfully submitted that the comment by the Examiner in the last two lines of the paragraph bridging pages 2 and 3 of the Office Action mailed February 10, 2005, is inapplicable to the claims as presently amended.

Takami, et al discloses a negative electrode carbonaceous material suitable for a lithium secondary battery, as well as a battery using this negative electrode carbonaceous material. According to Takami, et al., the negative electrode contains a carbonaceous material which has an exothermic peak at 700° C or more when measured by a differential thermal analysis, and an intensity ratio P_{101}/P_{100} of a (101) diffraction peak P_{101} to a (100) diffraction peak P_{100} of a graphite structure obtained by X-ray diffraction analysis, of 0.7-2.2; and absorbs and desorbs lithium ions. See column 3, lines 1-8. Other negative electrodes disclosed in Takami, et al., are described at column 3, lines 16-25, 38-44, 56-60 and 66-68; as well in column 4, lines 9-13, 17 and 18.

Note also column 20, lines 25-56; column 21, lines 3-22; column 22, lines 1-19 and 37-62; and column 23, lines 10-21, for other disclosures in connection with negative electrodes of the secondary battery of Takami, et al. These disclosures all refer to the carbonaceous material having a graphite structure that exhibits a

property of allowing reversible absorption and desorption of lithium ions to and from hexagonal-net-plane layers in the graphite structure. Note also, for example, example 1 in column 24 and particularly lines 23-29 thereof, disclosing that the carbonaceous material used was a graphitized carbon powder with an average particle size of 25 μm , which was distributed at a ratio of 90 vol.% within the range of 1-50 μm in a particle size distribution, and in which the ratio of particles with a particle size of 0.5 μm or less was 0 vol. % in the particle size distribution. Note also, inter alia, example 2 and the discussion in connection therewith at column 25, lines 20-26; and example 3 and the discussion in connection therewith at column 25, lines 52-59, describing particle size of the carbonaceous material.

Attention is particularly directed to column 7, lines 29-40, of Takami, et al., emphasizing that the carbonaceous material having the recited intensity ratio has appropriate displacements, twists and angles of the hexagonal-net-plane layers so that lithium ions diffuse more easily between the hexagonal-net-plane layers; and note also column 14, lines 21-39, disclosing that the carbonaceous material has a mean length L_a of a crystallite in the a-axis direction of graphite structure. This patent again refers to crystallite structure, e.g., at column 22, lines 37-62.

It is respectfully submitted that the disclosure in Takami, et al., having, e.g., crystallites and having hexagonal-net-plane layers with appropriate displacements, twists and angles, would have neither disclosed nor would have suggested the presently claimed structure, including the graphite powder having substantially completely the crystal structure, with the recited particle size of the graphite powder and with specified hexagonal and/or rhombohedral fraction of the crystal structure of the graphite powder, and the graphite powder having a deintercalating capacity for lithium of at least 320 mAh/g, and advantages thereof, as described in the foregoing.

The contention by the Examiner that the language in column 14, lines 30-43, of Takami, et al (that the carbonaceous material is of a crystallite structure in a hexagonal-net-plane layer) meets Applicants' claimed subject matter of an anode hexagonal crystal structure, is respectfully traversed, particularly insofar as applicable to the claims as presently amended. That is, the claims now expressly recite that the graphite powder has substantially completely the crystal structure. Thus, it is respectfully submitted that the present claims recite the graphite powder, and that such graphite powder has crystal structure, not to individual layers of the laminate thereof and/or crystallites of the carbonaceous material. Properly construing the language of the present claims, it is respectfully submitted that Takami, et al. would have neither disclosed nor would have suggested the graphite powder having substantially completely the crystal structure, with hexagonal-rhombohedral fractions thereof and with the powder having the recited particle size, the graphite powder having the recited deintercalating capacity, and advantages thereof as discussed previously.

The contention by the Examiner on page 2 of the Office Action mailed February 10, 2005, that it is inherent in the teachings of Takami, et al. that the capacity for the graphite crystal powder would be at least 320 mAh/g, is respectfully traversed. Initially, contrary to the conclusion by the Examiner, it is respectfully submitted that Takami, et al. does not teach the same material as in the present claims. It is respectfully submitted that the crystallinity of the graphite in Takami, et al. will be comparatively lower than that of the present invention. In this regard, note that Takami, et al. uses as starting materials, carbonaceous material such as mesophase pitch, mesophase spherulites and coke. In contrast, the present invention uses natural graphites. In addition, it is again emphasized that Takami, et

al. discloses materials having hexagonal-net-plane layers stacked so as to have displacements, twists and angles to one another. Clearly, the material in Takami, et al. is not the same as that of the present invention, and it is respectfully submitted that such material in Takami, et al. would not inherently have the deintercalating capacity formed as in the present claims.

It is again noted that, with regard to crystal planes (faces) (100) and (101) in the intensity ratio of P_{101}/P_{100} , Takami, et al. gives no definition with respect to crystal planes in the hexagonal crystal structure and in the rhombohedral crystal structure. Assuming, arguendo, that crystal plane (100) in Takami, et al. is of hexagonal crystal structure and crystal plane (101) is of rhombohedral crystal structure, described in the above-identified application, it is respectfully submitted that the intensity ratio of P_{101}/P_{100} in a range of 0.7-2.2 in Takami, et al. indicates an inclusion of hexagonal crystal structure contained in the graphite structure being less than 80% by weight.

For all of the foregoing reasons, it is respectfully submitted that Takami, et al. would have neither taught nor would have suggested and in particular would have taught away from, the presently claimed non-aqueous secondary battery, wherein the negative electrode thereof includes graphite powder having substantially completely a crystal structure, with hexagonal and/or rhombohedral fractions thereof and particle size thereof, the graphite powder having the recited deintercalating capacity, and advantages thereof.

Flandrois, et al. discloses a carbon anode for a lithium rechargeable electrochemical cell, and a process for its production. The carbon anode comprises a graphite-containing, carbon-containing material, characterized in that the material includes, prior to electrical cycling, at least a first phase constituted by graphite having a rhombohedral crystal structure and comprising a fraction of more than 10%.

See column 2, lines 3-10. Note also column 2, lines 33-40. See also the examples and Tables in connection therewith, showing, inter alia, passivation capacity (mAh/g).

It is respectfully submitted that Flandrois, et al. is concerned with providing a carbon-containing having increased rhombohedral structure, so as to increase passivation capacity. In contrast, while the present invention requires increased hexagonal crystal structure and decreased rhombohedral crystal structure so as to increase deintercalating capacity for lithium. It is respectfully submitted that Flandrois, et al. would have neither taught nor would have suggested the presently claimed invention, including, inter alia, ranges of hexagonal and rhombohedral fractions, and unexpectedly better results achieved in these ranges, as in the present invention; as well as other features of the present invention as discussed previously.

In particular, it is respectfully submitted that Flandrois, et al. would have neither taught nor would have suggested the deintercalating capacity for lithium as in the present claims. In connection therewith, it is noted that Flandrois, et al. refers to a passivation capacity ?, in the Tables associated with the various examples and comparative examples. As can be seen, for example, in Fig. 7 of Flandrois, et al., it is respectfully submitted that "?" is the distance between the curves 71 and 72. In contrast, it is respectfully submitted that the deintercalating capacity according to the present invention is between curve 72 in Fig. 7 of Flandrois, et al. and the point where curves 71 and 72 intersect the abscissa, as can be seen in the enclosed copy of Fig. 7 of Flandrois, et al. It is respectfully submitted that the passivation capacity as in Flandrois, et al. would have neither taught nor would have suggested the deintercalating capacity for lithium, of the graphite powder, according to the present invention, and advantages thereof.

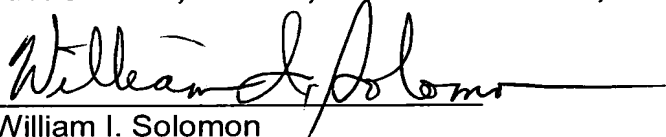
May 10, 2005

In view of the foregoing comments and amendments, reconsideration and allowance of all claims presently in the above-identified application are respectfully requested.

Please charge any shortage in the fees due in connection with the filing of this paper, including extension of time fees, to Deposit Account No. 01-2135 (Case No. 503.34465VV4) and please credit any excess fees to such deposit account.

Respectfully submitted,

ANTONELLI, TERRY, STOUT & KRAUS, LLP

A handwritten signature in black ink, appearing to read "William I. Solomon", written over a horizontal line.

William I. Solomon
Registration No. 28,565

WIS/ksh

Attachment:

Sheet 4 of 7 of U. S. 5,554,462, dated Sep. 10, 1996 (1 pg.)